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CEMENT DRAIN TILE

Published by
Universal Portland Cement Co.
CHICAGO — PITTSBURGH — MINNEAPOLIS
1912

Cement Drain Tile

With Evidence of their

Lasting Qualities

An Investigation
Conducted by the
INFORMATION BUREAU
UNIVERSAL PORTLAND CEMENT CO.

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INTRODUCTION

There is no place in the world where land drainage receives the thought and attention given it in America, and especially in the Northern States bordering on the Mississippi River. Not only are land owners interested, but township, county and state officials are required to assist in the work by providing township and county drains and by keeping the natural water courses open so that the land owner may have an outlet for his drains.

Without tile the wonderful development, past and present, in these states would be impossible.

It is the aim of this booklet to cite a few of the many instances where cement tile are proving satisfactory, and by explaining the cause of the few failures which have occurred, place information in the hands of the user which will enable him better to judge the quality of cement tile.

Cement Drain Tile

PORTLAND cement pipe and tile have been made and used in America for about fifty years and possibly longer in Europe. The early products usually were 24 inches long and were made by hand until 1890, when a machine was devised which packed the concrete into the molds mechanically, thus simplifying the operation.

It was not, however, until 1905 that a machine was put on the market capable of producing tile economically in the smaller sizes and in 12-inch lengths. About this time land drainage was attracting a great deal of attention in northern Iowa and southern Minnesota, and the development of the cement tile business in this territory has been rapid, and whether or not cement tile should be received favorably will be left to the reader.

To get at the facts, letters of inquiry were sent to farmers and tile users, township and county officials, engineers and contractors, also to European authorities. In all, about a thousand inquiries were made. Naturally a number of persons addressed were unable to give any help, yet much interest was manifested, and 335 opinions were received, only three of which were unfavorable to cement tile. Typical replies are herewith published by permission.

The following letters clearly indicate the high esteem in which concrete is held and express a firm belief in its adaptability for drain tile manufacture.

W. SOMMERVILLE COLBY
Surveyor
CERRO GORDO COUNTY
Drainage Engineer

Clear Lake, Iowa, Jan. 23rd, 1909

Mr. C. W. Boynton,
Chicago, Ill.

Dear Sir:-

I haven't had time to reply to your favor of last month and have put it off till now thinking I would be able to write you more fully in regard to the respective merits of cement and clay drain tile but I find myself still behind in my correspondence.

However I will say that it has been my observation that properly made cement tile get harder and are in better shape after being in the ground for a year than they were when they were put in and I have never seen a cement tile slack and spaul, shell and generally disintegrate either in the ground or when piled up as I have seen clay tile do. I am satisfied that if the mixture of sand, gravel and cement is properly proportioned, well mixed and the tile kept damp while seasoning that they will be at least equal to and frequently superior to the best grade of vitrified clay pipe.

Very truly yours,

W. Sommerville Colby

OFFICE OF

WM. H. RIGHTS, CITY CIVIL ENGINEER,

SURVEYOR OF BARTHOLOMEW COUNTY

COLUMBUS, IND., February 4th 190 9

Mr. C. W. Boynton,
Inspecting Engineer,
Universal Portland Cement Co.,
Chicago, Ill.

Dear Sir:-

Please excuse my delay in answering your of the 18th. In my work as Road Engineer I have for the past five years refused to put in any vitrified sewer pipe, excepting in a few cases to extend to proper length those already in and this practice is now general in all of the road work in this county. We have for the past year called for monolithic cement pipe built around a sheet iron form, which latter is left in. Have not used any separate cement pipe in sewers or land drainage, except monolithic reinforced concrete for large size sewers. Expect to begin using cement pipe this year in smaller size sewers. The objections to vitrified sewer pipe have been chiefly owing to their liability of freezing and bursting and their cost. In the use of clay tile for land drainage I have found no great amount of fault, excepting that in later years we are building more outlet or large drains and at some places going rather deep, with the earth pressure tending to break them. The larger sizes 16 to 30 inches are too expensive and have not sufficient strength.

As yet have not called for cement pipe for land drainage, but think good practice should require it. However, we in this county will have to educate our users of pipe up to them.

Hoping the above answers inquiry, I am

Yours truly,

Wm H. Rights.

Duncombe, Iowa, Dec. 1908.

Mr. C. W. Boynton,

Chicago, Ill.

Dear Sir:-

In reply to your inquiry of 7th inst. I will say that I have used about 12000 clay tile of various sizes of various factories from 4 in. to 14 in. I have always tried to get the best tile obtainable. Clay tile which were left on the grass land over winter did not withstand the freezing and thawing very well. In the spring when I went to put them in they were practically no good and I could not use them as they crumbled to nothing. A few of the real good burnt tile seemed to be in fair shape but not many.

I have had quite a few clay tile from one certain clay works that I hauled out thru the winter. In spring when I went to put them in the ground I could not use them at all, as they were no good. These clay tile I have in the ground are in three years from 3 to 8 feet deep. Those tile that are in deep are in the best shape. I dug up some of the others this spring and found that they were not fit to put back in the ground. That started me thinking of using cement tile. Since then I have used about 15000 from 5 to 12 in. and am still putting them in at the present writing. I have seen where cement tile were placed in the fall of 1907 as an experiment with only 6 in. of ground covering them. They withstood the freezing and thawing and were in far better shape in the spring of 1908 than when they were put in.

All of my tile drains can be dug into any time a man wants to look at them. Tilers claim that cement tile lay nicer, make a far better drain, as they are uniform in size and length. From my experience I find that after drawing them over 5 miles of rough and frozen roads, hardly ever is one broken. I have hauled for days and not broke a single tile, and consequently believe that cement tile properly made, are far superior to clay tile.

Yours truly,

(Signed) Patrick Ledden.

DR. W. MICHAËLIS, JR.
CONSULTING ENGINEER FOR THE CEMENT INDUSTRY
OFFICE AND LABORATORY
1118-1119 SCHILLER BUILDING
CHICAGO, ILL.
TELEPHONES: AUTOMATIC 8282 RANDOLPH 934

TRANSLATION

Mechanic-Technical Laboratory of the Technical High-School, Vienna.

Vienna, March 20, 1909.

Universal Portland Cement Co.

Chicago-Pittsburg.

Gentlemen:

In reply to your letter of January 29th 1909, we beg to make the following statement:

Concrete drain tiles or pipes (cylindrical tubes) have been extensively used in place of the commonly used clay pipes. Such concrete drain pipes are manufactured as thin as possible and the upper half of the cylinder is perforated with the necessary number of holes.

Furthermore, we wish to communicate to you our experience with regard to the durability of concrete pipes used for sewerage, for which purpose concrete has been used in Austria for the past 40 years. These concrete sewer pipes must necessarily behave in the same way as concrete drain pipes, if both are laid in underground water.

The conclusions to be drawn from practical experience perfectly correspond with what might reasonably be expected from Portland cement concrete by a person familiar with its physical properties. Portland cement concrete obtains its maximum durability, if it is kept in a moist atmosphere for a short period after being made and if it is afterwards permanently immersed in water.

This is identically the same treatment to which concrete drain pipes or sewer pipes are submitted after being made. They are permanently kept moist. The durability is thereby not lessened in the least in the long run; on the contrary, the excellent physical properties of these concrete pipes are continuously improved by it.

If we compare the former results with those obtained with the best clay pipes of the quality ordinarily used for drainage purposes, we find that clay pipes are certainly not improved by the contact with water. On the contrary they show signs of destruction after a comparatively short time. For this reason ordinary clay pipes must be considered to be inferior to Portland cement concrete drain tiles.

Respectfully submitted

(Signed): Krisch, Professor.

Translated by DR. W. MICHAËLIS, Jr.

July 20, 1909.

Mr. C. W. Boynton,

Inspecting Engineer,,

Chicago, Ill.

Dear Sir:-

In answer to yours of the 8th inst. in regard to my experience with clay and cement tile will say I have examined the cement drains on my farm in several places at different depths and in soil of different conditions as to moisture and in every place the only change I could detect was that they were a great deal harder than when they were first laid. I tried a little experiment (by accident) in my barnyard during the last winter. I had several tile both clay and cement standing on end on the ground. They became filled with water from snow and rain and repeatedly froze and thawed through the winter, the clay tile bursted and also scaled off in flakes while the cement tile were uninjured.

I also examined the cement tile in the companies yard at Elmore. The tile were then piled on the ground as they were taken off the racks, and as the ground is quite low there some of them became entirely submerged in mud and water, others on drier ground and others in the upper part of the piles and all with no protection whatever, where they stood all winter and froze and thawed as the weather changed and were exposed to every condition of weather that a Minnesota winter could produce; and though there were thousands of tile of different sizes, not one tile was injured. I believe that this is the severest test tile can have, a test that clay tile will not stand at all, as the best clay tile we can get will scale and slough off in half the time these tile laid there.

In the fall of 1908 several thousand tile (both clay and cement) were hauled out and scattered on the ground in this vicinity, where they intended to lay them in the fall and early winter, but owing to the unfavorable season they failed to get them into the ground. They laid out all winter, and in every case a large percent of the clay tile were ruined, while the cement tile were uninjured. My observation of the two kinds of tile have led me to decide that cement tile is the kind for me.

Yours truly,

(Signed) H. E. STEWART, ELMORE, MINN.

E. Howard Fitz
Prop. CEDAR PARK FARMS.

Notary Public
Justice of the Peace
Architect & Superintendent

Monterey, Minnesota Jan. 4 19 09

C. W. Boynton, Inspecting Engineer,

Chicago, Ill.

Dear Sir:-

Replying to your inquiry of Dec. 10th. I placed cement tile or curbing in a well on "The Cedar Park Farm," in the summer of 1883. This tile was 24 in., inside diam. The well has been in constant use during the intervening 25-1/2 years.

A portion of this time the well was covered by an open well house. Balance of the time by a platform resting on the cement well curb.

At this time the well lining shows no sign of crumbling or deterioration of this curb.

I had a line of 4 in. tile placed this same season (1883). I have never had any of this line of tile dug up so can't say how it's keeping. The drain is still working.

In 1886 I had another well put down, to accommodate other buildings. This I had curbed with 18 in. cement tile. I also laid some more 4 in. cement tile this season. Some of this tile I have had up; found it all in good condition.

I am confident from my experience and observation that cement tile if properly made will outlast any other tile on the market.

Yours truly,

E. Howard Fitz

IT is a well known fact that a large number of cement pipe were made and used with satisfaction in the vicinity of South Bend and for the purpose of determining more fully the details of the early manufacture of these pipe an investigator spent some time in this neighborhood.

He found that in the year 1871 Mr. Thomas Millen and his two sons were engaged in the manufacture of cement pipe, using cast iron molds. A number of outer forms of one size were employed with only one inner form. This necessitated the removal of the inner form immediately after the concrete had been placed.

On account of the high price of imported Portland cement, (the first car costing $9.12 per barrel) the manufacture of Portland cement was seriously considered and a plant was soon built and operated to produce cement for making pipe. Fig. 1 shows the abandoned plant in its present condition.

Fig. 1

The manufacture of pipe was discontinued in 1892, consequently it can be assumed that any pipe found in the vicinity of South Bend is at least seventeen years old.

Five miles from South Bend on South Bend Avenue, Mr. Jacob Young placed five pipe 8 inches in diameter across his driveway in the early eighties. (Fig. 3.) In 1899 the road was graded, the pipe taken up and they have lain at the side of the road ever since. Three of these pipe were shipped to Chicago and tested to determine their strength. They averaged 100,000 pounds total for the 2 ft. length. Fig. 2 shows a fracture of one of these

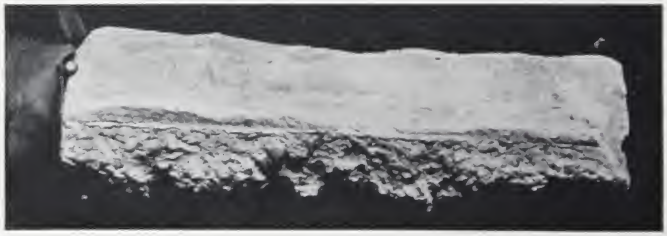

Fig. 2

Fig. 3

pipes as it came from the testing machine. It is interesting to note that a large percentage of the stones have been fractured, which indicates that the concrete is in excellent condition.

At Mr. Daniel Young's farm, just beyond that of his brother, Jacob, another culvert made of 10-inch pipe was placed across the road in 1884. These pipe are also in perfect condition. (Fig. 4.)

Under the road in the same vicinity are about fifteen large flat-bottomed pipe, size 22″ x 28″ (Fig. 5), also placed in 1884, which are in an excellent state of preservation.

The Studebaker Brothers' factory has been a large user of cement pipe and at present many drains are in use. One placed in 1875 is now giving perfect satisfaction, according to Mr. A. W. Peak, chief of the

Fig. 4

Fig. 5

factory fire department, who has worked for this firm for forty-four years. Mr. Studebaker says that the pipe have been in every way satisfactory. Due to changes made from time to time many have been removed, and some are lying around the lumber yard today. Fig. 6 shows two of them, one of 6-inch diameter and the other of 9-inch diameter.

Fig. 6

South Bend has many cement pipe sewers none of which have been abandoned or rebuilt because of the poor quality of the pipe. One of 15-inch diameter runs by the Oliver hotel, beginning at Washington and Main streets and running to Chapin on the north side of Washington. The ends can plainly be seen by looking down the man-hole. When examined the pipe was running about one-quarter full of water.

Fig. 7

This sewer was placed by Mr. G. H. De Frees, who still resides at South Bend.

Another sewer extends from Washington to Division, on the west side of Michigan Street, and according to Mr. L. H. Webster, a contractor, was placed in 1880.

Mr. Webster took the contract for the placing of a sewer of 10-inch pipe on Chapin street, beginning at Ford and running to Sample street. This sewer having a fall of only one foot in eight hundred, was the first contract which Mr. Webster ever took, consequently he remembers it well. The pipe came from the Millen plant and were made from South Bend Portland cement. Until four years ago this sewer was in actual service taking care of all the sewage of the Wilson Shirt factory, where

Fig. 8

Fig. 9

from three hundred to one thousand people were employed. At that time it became necessary to repair the street and enlarge the drain as the fast growing population required a sewer of larger capacity. It was then removed by Hoban & Roach and many of the pipe resold. A few are left in their yard (Fig. 7) and all are in perfect condition.

Brother Alfred of the University of Notre Dame, was one of the large consumers of culled tile from the Millen factory, and generally

Fig. 10

took care of all the pipe which were not salable as first quality. He used them on the campus and farms of the University. They were bought at one-quarter to one-half of the usual selling price. An 18-inch sewer of this pipe, placed in 1892, runs under the Niles road and still carries all the sewage from the University.

Another lot of 18-inch cement pipe is used on one of the Notre Dame farm roads and has been in place for twenty years. (Fig. 8.) Under another part of the same road two parallel lines of 22″ x 28″ oval pipe

Fig. 11

(Fig. 9) make a passage for hogs from one field to another. The pipe have now been in place since 1885, and were bought from the Millen factory.

A line of 12-inch pipe at least twenty years old, empties into Notre Dame lake (Fig. 10) and carries the surface water from the adjacent hill slope.

The pipe made in South Bend were shipped out for use in neighboring towns and for highway culverts. At Mishawaka a large number of these pipe were used with entire satisfaction. The Dodge Manufacturing Company has a concrete sewer, size 22" x 28", the inlet of which is shown in photograph Fig. 11. According to Mr. Hos-

Fig. 12

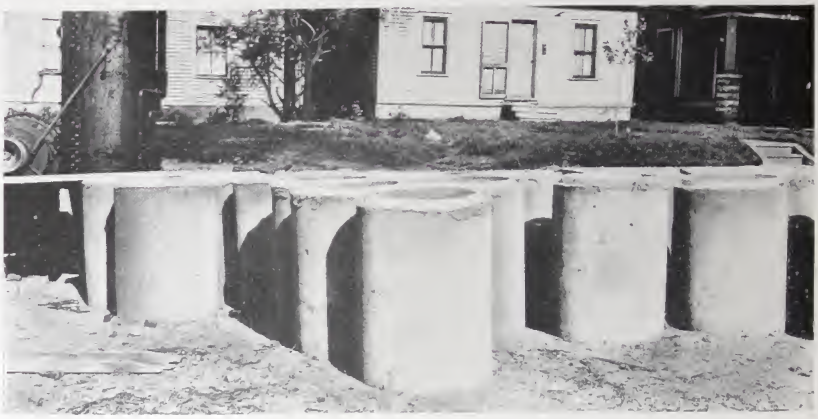

Fig. 13

ford, vice-president of the company, this sewer has been in use since 1888. Mr. Tupper, the engineer, says the sewer receives very hard usage as three or four barrels of sludge from the water softener are dumped into it daily.

Prior to 1883 a large number of 18-inch pipe were laid under Race street, Mishawaka, and through the old head gate at the foot of the street. (Fig. 12.) A new head gate was placed and as the old one interfered with the flow of water, it was removed and the pipe taken out to be relaid elsewhere. (Fig. 13.) The pipe are in perfect condition and the web-like "water marks" from the removal of the mold can still be seen on their inner surface. (Fig. 14.) Mr. G. F. Stoeckinger, a sewer con-

Fig. 14

Fig. 15

tractor, is authority for the date of the installation of these pipe. In that year he came to this country and worked on the head gate during a flood and saw the pipe at that time. When a piece was broken from one of these pipe all the stones including a piece of red granite were fractured.

In about the year 1888 Mr. Adam Klaer bought 8-inch pipe from South Bend which he placed as a culvert at the crossing in front of his home in Mishawaka. In 1903, when the street was paved, the pipe were taken up and Fig. 15 shows one of them in perfect condition.

Fig. 16

Fig. 17

South Bend and northern Indiana are not the only places where good examples of concrete pipe were found. A number of cities in southern Michigan received pipe from South Bend and later from a plant established at Battle Creek in 1882 by Mr. M. M. Lewis, and operated by him, using South Bend Portland cement and the same type of molds as used by the Millens. Fig. 16 shows the end of a line of 24″ x 30″ concrete pipe which runs under the Coldwater road about one-half mile from Battle Creek and carries the water from a small creek through to the lake beyond. The water runs the year round and Mr. Harry Lewis is authority for the statement that the pipe were made in about 1886. They are 10 feet below the level of the road but none are cracked.

Fig. 18

The pipe which is shown in Fig. 17 is 15 years old and is located at Hamblin avenue and Putnam street in Battle Creek and drains the water from an open ditch into the Kalamazoo River. Fig. 18 shows two lines of pipe, one 18-inch diameter and the other 24″ x 30″ oval. The large pipe were laid twenty years ago, and the smaller pipe are of about the same age. Fig. 19 shows an 18-inch pipe, first placed in 1880 at Niles, Michigan, and recently removed from a sewer which, according to Mr. Fogus, superintendent of the Board of Public Works, is still doing service. In the same vicinity is a line of 24″ x 30″ pipe, made at South Bend, and in as good condition as the one shown in the photograph.

Fig. 19

Elkhart, Indiana, boasts of a number of concrete pipe sewers. About 4,000 feet of 30-inch pipe placed in 1883 in Second street have cost nothing for repairs and are still doing service. On nine of the side streets 12-inch cement lateral sewers empty into the main sewer and carry all the sewage from the side streets.

Fig. 20

In all the investigations of the use of cement pipe in northern Indiana and southern Michigan, but one instance can be cited where a cement pipe showed a tendency to deteriorate. In 1884 Brother Alfred of the University of Notre Dame made 10-inch pipe from natural cement in old iron molds discarded by the Millens. These were installed in a drain 500 ft. long and in 1904 were removed and replaced by pipe of larger capacity. Brother Alfred stated that these pipe were in good condition when taken from the ground. The pipe were then left along the line of the drain (Fig. 20) and it was one of these natural cement pipe that disintegrated in part during the next few years. Considering the fact that these pipe were manufactured by one without experience and of natural cement which is not recommended, it is remarkable that after long exposure to freezing and thawing only one length showed signs of disintegrating.

The city of Allegheny, Pa., began laying sewers of concrete pipe in 1872 and the records show 13 different sewers laid prior to 1878. Mr. Chas. W. Ehlers, for many years Superintendent of the Bureau of Engineering and Surveys of Allegheny, and now Assistant Superintendent in the same Bureau of Greater Pittsburg, states that in recent years he has had occasion to connect other sewers with those of concrete pipe. In making the connections he has found the concrete in every case to be hard and sound.

Brooklyn, N. Y., at one time used cement sewer pipe exclusively, the first pipe being placed about 1861. Today, over 400 miles of cement pipe are in use and giving good service. Fig. 21 shows a pipe which had been in use for nineteen years and was in good condition when removed in 1909.

Fig. 21

Mr. A. J. Provost, Consulting Engineer to the President of the Borough of Brooklyn, 1902-1906, says: "With 450 miles of cement pipe in satisfactory service Brooklyn's practice in this direction cannot be ignored, and in addition thereto the extensive use of cement sewer pipe in England, Germany, France, Belgium and Australia, creates a situation which the American cities, other than Brooklyn, must sooner or later take into account."

Concrete pipe have made possible the wonderful development by irrigation in the Loveland-Ft. Collins-Greeley district of Colorado, where for years they have been used in large quantities. Eighteen years ago the city of Greeley constructed a storm water sewer of concrete pipe and recently, upon official examination, the pipe were found to be in perfect condition although they drain the worst alkali section in the city.

Fig. 22 shows an 8-inch concrete pipe 2 feet in length which has been in irrigation service for thirteen years at Santa Paula, California, and showed a compressive strength of 61,000 pounds. This line was made continuous by joining the pipe with mortar a portion of which is still adhering to the end of the section shown in Fig. 22.

To determine the behavior of cement tile in service many were taken up and tested and in no case did they show a strength less than tile from the same plant which had been tested to ascertain the average quality of the product of the plant. In one instance two different lots of tile from the same plant were tested and those

Fig. 22

Fig. 23

which had been in the ground two years (Fig. 23) sustained a load of 15,000 pounds, while tile six months old, representing the product of the plant as sold to the consumer, broke at 10,000 pounds. Possibly all of this difference of fifty per cent in favor of the tile in the ground was not due to the additional aging in the ditch, but undoubtedly the tile did gain a large portion of its strength after being put in the ground. This is just

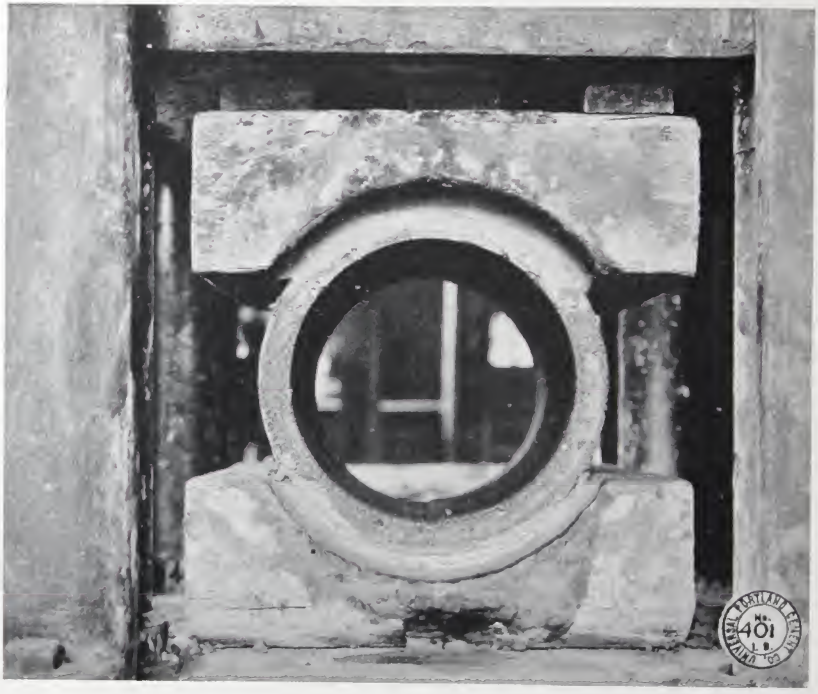

Fig. 24

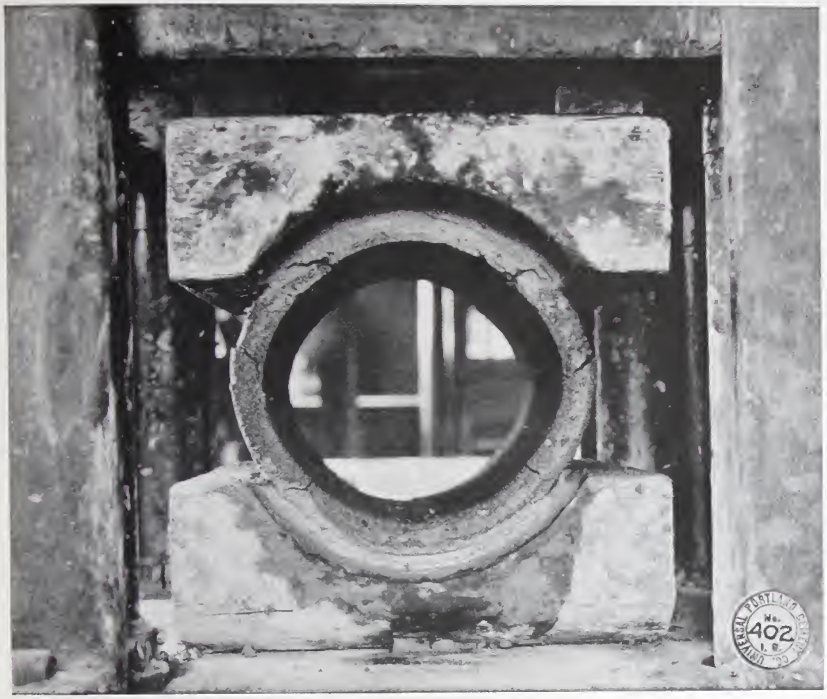

Fig. 25

what one would expect, as every authority on concrete agrees with Professor Krisch in his statement that:

> "Portland cement concrete obtains its maximum durability (strength), if it is kept in a moist atmosphere for a short period after being made and if it is afterwards permanently immersed in water. This is identically the same treatment to which concrete drain pipes or sewer pipes are submitted after being made. They are permanently kept moist. The durability is thereby not lessened in the least in the long run; on the contrary, the excellent physical properties of these concrete pipes are continuously improved by it."

The method employed in making these tests is illustrated in Figs. 24 and 25, which show a tile before and after crushing. The load was applied to saddles covering the upper and lower thirds of the tile which were imbedded in plaster to insure a uniform bearing. This method of testing gives a higher strength than other methods frequently used, but was chosen because it would give more accurate results with a testing machine of large capacity.

Concrete pipe are particularly desirable because of their uniform shape, true circular form and square clean ends (Fig. 26). The lack of uniformity in the shape of a line of tile will materially affect the flow of water through the drain in which they are laid. One ill shaped tile may seriously decrease the capacity of the entire line. Two tile are represented

Fig. 26

in Fig. 27, placed end to end, one of which is of true circular form, while the other is warped. This is an illustration of the loss of capacity which will result from a single warped tile in a drain. The solid black portion of Fig. 27 shows the capacity lost.

Irregularity in shape also causes an additional loss, due to increased friction at the joints and where tile match poorly, they often carry away large quantities of soil, causing sinks and often clogging the drain.

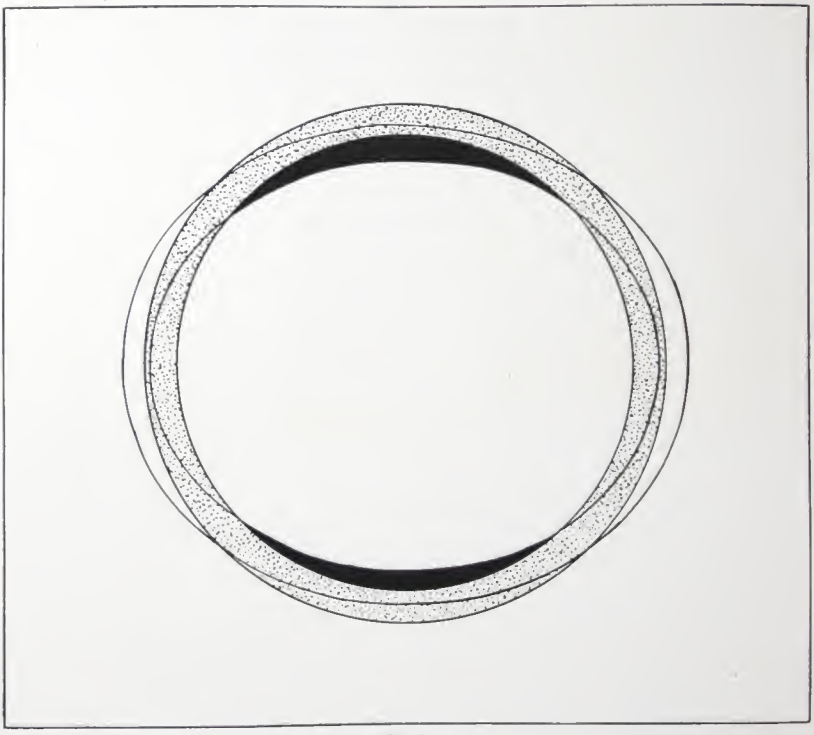

Fig. 27

Other things being equal, a cement tile containing a large per cent of pores or voids will be weaker than a tile containing less voids. The strength of tile or other concrete products will vary with the density. It is not hard to understand why a weak, porous tile should fail after continuous freezing and thawing and why a dense, strong tile (Fig. 28) should last indefinitely. Though cement tile showing absorption as high as twelve per cent have resisted frost action without showing any tendency to disintegrate, it is not sufficient argument for porous cement tile since they should be made as impervious as is commercially possible. Cement tile with an unnecessarily high percentage of voids are condemned absolutely.

Fig. 28

During this investigation no failures of Portland cement tile were found, excepting where the tile had been made of a very lean mixture or were carelessly cured.

To cite a case in point: two cement tile drains made from the same lot of tile were found, in which the tile failed by gradually softening. These tile were made about 1887 and were left in the pile for two years. According to the best authority it was possible to locate, the tile were made by a man without previous experience, from a mixture of one part of cement to about eight parts of sand with only enough water to hold the mass together. Naturally the tile were very poor from the beginning and were not salable; but after the business failed, the tile were sold as a job-lot for eighty dollars, there being about eight thousand feet of the various sizes. These tile were found weak and would not bear removal, though the drain formed by them was still working.

Considering the mixture of which these tile were composed and the carelessness with which they were evidently made, it is surprising that they have lasted so long. Without giving the facts in the case, this failure is cited maliciously as typical of cement tile. These tile did not fail

because of any inherent weakness in the materials, but because they were made carelessly and with insufficient cement.

The only other failure of cement tile which appeared at first to be serious, occurred after a lot of tile had lain in a swamp through two winters. When the time came to put them in the ground a few of those which had been in water and subjected to excessive freezing and thawing for two seasons were found to be weak. Some two hundred feet were broken up and used as filling. As attention was not called to these until after they were broken up it is impossible to say just what their condition was. They were some of the first tile made by a newly started factory which was one of the first plants established. Though the owner of the plant stated that these tile were just like thousands of others made about the same time, he was probably mistaken, for other tile produced by him and subjected to the same weather conditions have given excellent results. It is a fact, however, that these tile were made from a leaner mixture than is now considered good practice.

When cement tile were first made by machine, very lean mixtures were used and little or no attention paid to curing them. Considering that the tile machine was a new thing and that usually those who established plants were not familiar with the making of cement products, it is surprising that more failures have not occurred. In its short existence the cement tile business has developed from a hit-and-miss proposition into an industry which ranks high when compared with plants manufacturing tile of other materials. In many places the original factory costing a few hundred dollars has either been abandoned or remodeled, and the modern plant represents an investment of several thousands of dollars. The manufacturers have discovered that lean mixtures are objectionable, and careful attention is now given to curing, and cement tile are today equal or superior to those made of any other material.

Two tests for the quality of cement tile are the "ring" and the absorption. Since it is impossible to make a weak, porous cement tile give a clear, metallic "ring" when struck with a hammer or piece of metal, this test is quite satisfactory. The absorption test consists in weighing the cured tile before and after placing in water for twenty-four hours. The per cent of absorption which should not exceed 8%, is determined by dividing the weight of water absorbed, by the original weight of the tile.

It is a fact that some cement tile plants turn out better tile than others because favored with better natural materials. The same is true of many other industries.

Cement tile should not be made with a length or diameter of more than 30 inches without being reinforced and all large tile should have a wall thickness of at least 1/12 the diameter. When cement tile are made along the line of the ditch or in the open they should be made by the poured process and allowed to remain in the mold for at least 12 hours. When the molds are removed the tile should be covered with hay or straw and kept moist for 10 days. The straw can then be removed or allowed to dry but the tile should not be used until at least 30 days old. A good quality of tile must not be expected if the concrete is allowed to dry immediately after the tile are formed.

Fig. 29

Fig. 29 shows three concrete pipe. No. 1 was made at South Bend, Indiana, and placed in a highway culvert about 1888, and was removed after serving 18 years. No. 2 is a 4" x 24" cement pipe taken from the farm of Mr. Howard Fitz, at Monterey, Minnesota, and had been in service since 1883. No. 3 is a 3" x 24" pipe from Farmers City, Illinois. The pipe was originally placed in 1871 to drain a cellar under Bean's Hall. After serving fifteen years it was removed to make way for a larger drain. A portion of these pipe were relaid and are still in service. These examples are cited as practical demonstrations of the remarkable lasting qualities of concrete pipe.

Fig. 30

Fig. 31

Fig. 30 shows some 15-inch cement tile which were laid in a county drainage ditch near Armstrong, Iowa, washed out the first season, and have since been subjected to the most severe ditch conditions of alternate freezing and thawing. This picture serves to illustrate forcibly the lasting qualities of concrete pipe. It also shows the need of a concrete head wall (Fig. 31) which would undoubtedly have prevented the washout.

Numerous other instances could be cited and photographs shown which would illustrate that cement is a suitable material for the manufacture of drain tile; however, the best proof of this is the fact that thousands of farmers who are well fitted to judge of drain tile are buying and laying cement tile in greater quantities each year.

¶ UNIVERSAL is the highest grade, purest Portland cement made. It is the safest to use because it is absolutely uniform in quality. We make sure that it is uniform in soundness, strength, fineness and setting qualities by taking a sample for testing four hundred and fifty times an hour.

¶ As the finished product comes from the mill, it passes on a conveying belt to the bin. About half way to the bin, stands an automatic machine which takes a certain quantity from it every eight seconds for testing. This automatic sampling device was originated and perfected by this Company and is used by us exclusively. Every sixty minutes, these samples are gathered up and taken to our laboratories, where they are subjected to the most severe tests known. This method of obtaining fair samples and of testing UNIVERSAL is an example of the painstaking and exacting care exercised at every step in the process of its manufacture.

UNIVERSAL PORTLAND CEMENT CO.

CHICAGO —— PITTSBURGH —— MINNEAPOLIS

Annual Output—12,000,000 Barrels